WRITTEN AMENDMENT

(Amendment under Patent Law Section 11)

4. Article for amendment: Specification and Claims

5. Amendment:

(1) The Specification, page 5, paragraph [0019], line 1, insert "in which a gate electrode is embedded in a trench via a gate insulating film" before "has a trench gate structure";

line 2, insert "by etching" before "formed"; and

line 3, change "thermal oxidation method" to "a high-temperature diluted pyrogenic oxidation method which is performed by diluting the reaction gas with an inert gas and is performed at 950°C or more".

(2) The Specification, page 5, paragraph [0020], line 1, insert "at the time of forming the trench gate structure in which the gate electrode is embedded in the trench in the semiconductor substrate via the gate insulating film" before "firstly";

line 1, delete "semiconductor substrate"; and

line 3, change "for example" to "given conditions".

(3) The Specification, page 5, paragraph [0021], is amended as per attached sheet.

(4) The Specification, page 5, paragraph [0022], is

amended as per attached sheet.

(5) Claims, page 27, Claim 1, line 1, insert "in which a gate electrode is embedded in a trench via a gate insulating film" before "has a trench gate structure";

line 2, insert "by etching" before "formed"; and

line 3, change "thermal oxidation method" to "a high-temperature diluted pyrogenic oxidation method which is performed by diluting the reaction gas with an inert gas and is performed at 950°C or more".

(6) Claims, page 27, Claims 2, 3, 4, 5, 6, and 7 are amended as per attached sheet.

(7) Claims, page 27, delete "Claims 8, 9, and 10"; and

Claims, pages 27 to 28, delete "Claim 11".

6. List of Attached Documents

(1) The Specification, pages 5 and 5/1; and

(2) Claims, pages 27 and 28.

Attached Document:

(1) The Specification, pages 5 and 5/1:

Means for Solving the Problems

[0019]

In order to solve these problems, in the invention, there is provided a method for producing a semiconductor device, which has a trench gate structure in which a gate electrode is embedded in a trench via a gate insulating film, being characterized by having the steps of:

forming an oxide film by a CVD method on an inner wall of a trench formed by etching in a semiconductor substrate;

forming a thermally oxidized film on an interface between the oxide film and the semiconductor substrate by a high-temperature diluted pyrogenic oxidation method in which a reaction gas is diluted with an inert gas and which is performed at 950°C or more; and

forming a gate insulating film containing the oxide film and the thermally oxidized film in the trench.

[0020]

According to the method for producing the semiconductor device, at the time of forming the trench gate structure in which the gate electrode is embedded in the trench in the semiconductor substrate via the gate insulating film, firstly, an oxide film is formed with good uniformity on an inner wall

of a trench by a CVD method such as a reduced pressure CVD method having good coverage characteristics and, then, a thermal oxidation treatment of given conditions is performed by a pyrogenic oxidation method and, thereafter, oxygen is supplied to a surface of the semiconductor substrate via the oxide film formed by the CVD method, to thereby form a thermally oxidized film on an interface thereof. By such procedures as described above, an excellent gate insulating film which is not locally thinned and has thickness of good uniformity can be formed in the trench. Besides, by forming the thermally oxidized film on an interface between the oxide film by the CVD method and the semiconductor substrate, a stable interface having a low interface state density can be obtained.

[0021]

Further, according to the invention, there is provided a method for producing a semiconductor device, which has a trench gate structure in which a gate electrode is embedded in a trench via a gate insulating film, being characterized by having the steps of:

forming an oxide film on an inner wall of a trench formed in a semiconductor substrate by a CVD method such that it has 59% to 95% of film thickness of a gate insulating film to be finally formed;

forming a thermally oxidized film by a thermal oxidation method on an interface between the oxide film and the

semiconductor substrate; and

forming the gate insulating film containing the oxide film and the thermally oxidized film in the trench.

[0022]

According to such method for producing the semiconductor device as described above, at the time of forming the trench gate structure in which the gate electrode is embedded in the trench in the semiconductor substrate via the gate insulating film, a ratio of the film thickness of the oxide film to be formed on the inner wall of the trench by the CVD method is allowed to be from 59% to 95% of the film thickness of the gate insulating film to be finally formed and, after forming such oxide film, the thermally oxidized film is formed by the thermal oxidation method on an interface between the thus-formed oxide film and the inner wall of the trench to thereby form the gate insulating film. By these arrangements, the gate insulating film, which is not locally thinned, having a film thickness of good uniformity can be formed in the trench and, then, a longer lifetime can be aimed for. Further, by forming the thermally oxidized film on the interface between the oxide film by the CVD method and the semiconductor substrate, a stable interface having a low interface state density can be obtained.

Further, according to the invention, there is provided a method for producing a semiconductor device, which has a

trench gate structure, being characterized by having the steps of:

forming an oxide film on an inner wall of a trench formed in a semiconductor substrate by a CVD method such that it has 59% to 95% of film thickness of a gate insulating film to be finally formed;

forming a thermally oxidized film by a thermal oxidation method on an interface between the oxide film and the semiconductor substrate; and

forming the gate insulating film containing the oxide film and the thermally oxidized film in the trench.

According to the method for producing the semiconductor device, a ratio of the film thickness of the oxide film to be formed on the inner wall of the trench in the semiconductor substrate by the CVD method is allowed to be from 59% to 95% of the film thickness of the gate insulating film to be finally formed and, after forming such oxide film, the thermally oxidized film is formed by the thermal oxidation method on an interface between the thus-formed oxide film and the inner wall of the trench, to thereby form the gate insulating film. By these procedures as described above, the gate insulating film having a film thickness of good uniformity and a long lifetime can be formed in the trench. Further, between the gate insulating film and the semiconductor substrate, a stable interface having a low interface state density comes to be

obtained.

Advantage of the Invention

[0023]

In the method for producing the semiconductor device according to the invention, at the time of forming the gate insulating film on the inner wall of the trench of the semiconductor device, firstly, the oxide film is formed by the CVD method and, then, the thermally oxidized film is formed between the oxide film and the semiconductor substrate by the thermal oxidation method.

Attached Document:

(2) Claims, pages 27 and 28:

Claims

1. (Amended)

A method for producing a semiconductor device, which has a trench gate structure in which a gate electrode is embedded in a trench via a gate insulating film, being characterized by comprising the steps of:

forming an oxide film by a Chemical Vapor Deposition method on an inner wall of a trench formed by etching in a semiconductor substrate;

forming a thermally oxidized film on an interface between the oxide film and the semiconductor substrate by a high-temperature diluted pyrogenic oxidation method in which a reaction gas is diluted with an inert gas and which is performed at 950°C or more; and

forming a gate insulating film comprising the oxide film and the thermally oxidized film in the trench.

2. (Amended)

A method for producing a semiconductor device, which has a trench gate structure in which a gate electrode is embedded in a trench via a gate insulating film, being characterized by comprsing the steps of:

forming an oxide film on an inner wall of a trench formed

in a semiconductor substrate by a Chemical Vapor Deposition method such that it has 59% to 95% of film thickness of a gate insulating film to be finally formed;

forming a thermally oxidized film by a thermal oxidation method on an interface between the oxide film and the semiconductor substrate; and

forming the gate insulating film comprising the oxide film and the thermally oxidized film in the trench.

3. (Amended)

The method for producing the semiconductor device according to Claim 1 or 2, being characterized in that the semiconductor device is further comprising an electric field relaxation region, a base region, which is of a conductivity type opposite to the electric field relaxation region, formed on the electric field relaxation region, and a source region, which is of a conductivity type same with the electric field relaxation region, selectively formed on a surface layer of the base region, the trench is in contact with the source region and reaches an inside of the electric field relaxation region by passing through the base region.

4. (Amended)

A method for producing a semiconductor device, which has a trench gate structure, being characterized by comprsing the steps of:

forming an oxide film on an inner wall of a trench formed

in a semiconductor substrate by a Chemical Vapor Deposition method such that it has 59% to 95% of film thickness of a gate insulating film to be finally formed;

forming a thermally oxidized film by a thermal oxidation method on an interface between the oxide film and the semiconductor substrate; and

forming the gate insulating film comprising the oxide film and the thermally oxidized film in the trench.

5. (Amended)

The method for producing the semiconductor device according to any one of Claims 1 to 4, being characterized in that a bottom portion of the trench is formed in a round shape.

6. (Amended)

The method for producing the semiconductor device according to any one of Claims 1 to 3, being characterized in that width of the trench is from 0.4 μm to 0.6 μm.

7. (Amended)

The method for producing the semiconductor device according to any one of Claims 1 to 4, being characterized in that the oxide film is formed by using a gas comprising dichlorosilane and dinitrogen monoxide as a raw material.